

Research on the Impact of the Dual Pilot Policy of Low-Carbon City and Green Finance on the Corporate Green Investment

Xiaonuo Xu *

Nanjing Normal University, Business School, Nanjing, Jiangsu Province, China

*Corresponding Author

ABSTRACT

To actively address climate change and promote emission reduction and carbon mitigation, the Chinese government has introduced environmental regulation policies such as low-carbon city pilots and green finance reform innovation pilot zones to drive the green and low-carbon transformation of the economy. Corporate green investment plays an indispensable role in this process. Against this backdrop, this paper treats the implementation of China's low-carbon city pilots and green finance reform innovation pilot zones as a quasi-natural experiment. Based on a sample of A-share listed companies in China from 2007 to 2022, the study employs a multi-period difference-in-differences (DID) approach to empirically examine the synergistic effects of these two pilot policies on corporate green investment. It also compares the differences in the implementation effects of dual pilot policies (low-carbon city and green finance reform innovation pilot zones) versus single pilot policies. The findings reveal that: (1) both the low-carbon city pilot and the green finance reform innovation pilot zone policies significantly promote corporate green investment, (2) the dual pilot policies effectively enhance the scale of corporate green investment, and (3) the dual pilot policies have a stronger impact on promoting corporate green investment compared to the implementation of either the low-carbon city pilot or the green finance reform innovation pilot zone alone, indicating a synergistic effect between the two policies. From the perspective of corporate green investment, this study provides theoretical support for promoting corporate green and low-carbon transformation and the green development of the economy. It offers policy recommendations for advancing low-carbon urban green development practices, including summarizing and promoting pilot experiences, adopting differentiated strategies tailored to local conditions, strengthening regional green innovation cooperation, and encouraging the synergistic integration of "environmental governance" and "financial development."

KEYWORDS

Low-Carbon City Pilot Policy; Green Finance Reform and Innovation Pilot zone; Corporate Green Investment; Policy coordination

1. INTRODUCTION

At present, climate change is a common challenge facing the world. Reducing carbon emissions and accelerating the green and low-carbon transformation of the economy have become urgent practical problems to be solved by all countries in the world. As the country with the largest carbon emissions, China is facing huge pressure to reduce carbon emissions. In 2020, China proposed to achieve the goal of "carbon peak" by 2030 and "carbon neutrality" by 2060 (hereinafter referred to as the "two-carbon" goal), and took carbon reduction as the key strategic direction of ecological civilization construction during the 14th Five-Year Plan period. In recent years, under the guidance of Xi Jinping's thought on ecological progress, China has incorporated the "two-carbon" goal into the overall layout

of ecological progress and overall economic and social development, and achieved remarkable results in addressing climate change. The party's 20th annual report pointed out that "promoting green and low-carbon economic and social development is the key link in achieving high-quality development". To this end, China unswervingly follows the path of green, low-carbon and sustainable development, and pursues low-carbon economic transformation and green and high-quality development. However, low-carbon economic transformation and green development require a large amount of green investment (Li et al., 2021), and expanding the scale of corporate green finance is of great significance for realizing the green transformation of China's economy and improving global environmental governance (Tian et al., 2020). However, due to the characteristics of high cost, high risk and uncertain income, etc, enterprises often do not take the initiative to make green investment (Irfan et al., 2022). In this context, how to promote the change of enterprise investment wind direction is an important starting point to explore the low-carbon economic transformation.

For a long time, China's carbon reduction has mainly focused on administrative, tax and other environmental regulations, which has played a positive role in effectively controlling environmental pollution. Environmental regulation can encourage enterprises to actively participate in environmental governance through policy pressure (Wang Bing et al., 2017, Cui Guanghui and Jiang Yingbing, 2019), or promote the increase of corporate green investment through strengthening government supervision (Xie Dongming, 2020). Among the implemented environmental regulation policies, the pilot policies of low-carbon cities are widely concerned by policy makers and scholars at home and abroad. The low-carbon pilot policy was first proposed in 2010 and gradually piloted in three batches in 2010, 2012 and 2017, currently covering 81 cities in China. According to the Progress Assessment Report of National Low Carbon City Pilot Work released by China in 2023, the carbon emission intensity of 95% of the pilot cities decreased significantly between 2017 and 2022, at the same time, the pilot city economy achieved effective quality improvement and reasonable quantitative growth.

However, with the transformation of China's economic development model, environmental regulations alone can no longer meet the needs of green economic development. In order to make up for the lack of traditional environmental regulations, the country has vigorously developed green finance in recent years. In 2017, the pilot policy, the original intention is to allocate financial resources on the supply side: on the one hand, to provide support for green enterprises and encourage them to make more breakthroughs in resource utilization, environmental protection technology and sustainable development, on the other hand, to exert pressure on polluting enterprises to increase investment in environmental protection and realize green transformation. In 2023, the Central Financial Work Conference proposed to do five major articles on "science and technology finance, green finance, inclusive finance, pension finance, pension finance and digital finance", and clarified the high-quality development orientation of green finance. However, at present, China is still in the primary stage of the development of green finance, and what role the green finance plays in the green transformation and development of Chinese enterprises still remains to be verified.

To this end, this paper aims to explore the following urgent problems to be solved: can the policy combination of low-carbon city and Green Finance Reform and Innovation Pilot zone promote enterprises to increase green investment? Is the impact of the dual pilot policy more effective than the single pilot? Will the implementation order of the pilot policies affect the effect of the dual policies on the corporate green finance? Clarifying the above issues is crucial to the realization of the two-carbon target, and has important policy implications for further expanding the scope of the pilot project and promoting policy coordination.

2. LITERATURE REVIEW

2.1. Research Status of Low-Carbon City Pilot Policy

At present, a lot of studies at home and abroad have discussed and verified that the pilot policy of low-carbon cities is aimed at reducing carbon emissions (Song et al., 2019, Liu et al., 2022, Zeng et al., 2023, Li et al., 2023), improve ecological efficiency (Wang et al., 2023), and promote the upgrading of industrial structure (Zhang et al., 2021, Liu Fang, 2022), improve green total factor productivity (Yu et al., 2020, Chen et al., 2021), to promote labor and employment (Yan Lipeng and Mou Junlin, 2023), and other aspects of the effectiveness. Some studies link Low-Carbon City Pilot Policy with enterprise behavior, and find that Low-Carbon City Pilot Policy can improve the technological innovation ability of enterprises (Li Linhong, et al., 2019, Xu et al., 2020, Xiong Guangqin, et al., 2020), promoting enterprise R & D investment (Huang et al., 2021), and improving enterprise labor investment (Cao et al., 2023).

2.2. Research Status of Green Finance Reform and Innovation Pilot Zone Policy

As for the concept of green finance, many scholars, international organizations and government agencies have defined this, but no unified international consensus has been formed. In foreign studies, the earliest American Traditional Dictionary (2000) defined green finance as "environmental finance (Environmental Finance)", placing financial industry and environmental protection in a unified framework, emphasizing that finance promotes economic development and pays attention to the pollution of production process. Domestic research, in 2016, the People's Bank of China and the original seven ministries issued "about building green financial system guidance", the official put forward the definition of green finance, green finance refers to "to support the environment improvement, climate change and resource conservation and efficient use of economic activities, namely the environmental protection, energy saving, clean energy, green transportation, green building in the field of project investment and financing, project operation, risk management and provide financial services".

As China has established a perfect green finance policy framework system in recent years, the domestic academic circle has also begun to pay more and more attention to the evaluation of the implementation effect of green finance policies. Some studies separately discuss the role of different types of green finance policies, It is found that green finance policies such as green credit policies, green bonds and carbon emission right trading policies can help to strengthen enterprise investment and financing (Liu et al., 2017, Su Dongwei and Lian Lili, 2018, Ning Jinhui, et al., 2021), improve environmental performance (Hu Jun et al., 2020, Zhan Hua, 2021, Wang Xin and Wang Ying, 2021), promote green innovation of enterprises (Lu Jing et al., 2021, Wang Xiuhua and Liu Jinhua, 2021) and upgrade the ESG rating, But it will also lead to overinvestment (Liu et al., 2017, Su Dongwei and Lian Lili, 2018, Li Rong and Liu Luqian, 2021) and increase the risk of green bleaching of enterprises (Su Dongwei and Liu Ziming, 2023) and other adverse effects.

Besides, as a representative green finance policy implemented by China, Research on the pilot policies of the Green Finance Reform and Innovation Pilot zone, Mainly from the following two aspects: on the one hand, Existing studies have found that the pilot policies of the Green Finance Reform and Innovation Pilot zone can promote the provincial environmental pollution reduction (Huang and Zhang, 2021), improve the provincial technology innovation performance (Wang et al, 2022, Liu and Xiong, 2022), promote regional green development (Wang et al., 2021), improve regional total factor productivity (Zhang et al., 2023), and promote economic green transformation (Hu et al., 2023). On the other hand, some studies discussed the impact of the pilot policies of Green Finance Reform and Innovation Pilot zone on enterprise technological innovation at the micro level, but have reached no unanimous conclusion. Liu and Wang (2023) and other scholars show that the establishment of the establishment of the pilot zone promotes the green patent output of enterprises by increasing their R

& D investment. However, Zhang (2023) and other scholars believe that the incentive effect of the pilot policy in the green innovation of enterprises is not significant. In addition, some studies focus on the positive impact of the pilot policies of the Green Finance Reform and Innovation Pilot zone on reducing corporate debt financing costs (Shi et al., 2022, Zhang, 2023), improving the investment efficiency of enterprises (Chen et al., 2022) and enhancing the long-term value of enterprises (Zhao et al., 2023). However, some studies have found that environmental governance only relying on green financial policies lacks obvious constraints, and there are excessive investment and green bleaching risks of enterprises (Liu et al., 2017, Su Dongwei and Lian Lili, 2018, Yu et al., 2020). Therefore, the role of green finance policy needs to be analyzed from other perspectives.

2.3. Research Status of Corporate Green Finance

There is no unified definition of corporate green investment in academia. The definition of green investment is represented by Voica et al. (2015), which believes that green investment refers to the low-carbon investment made by enterprises in renewable energy, clean environmental technology and climate change. In domestic research, the definition of green investment by Tang Guoping (2013) is widely adopted, that is, all investment related to environmental protection and pollution control should be included in the category of green investment, that is, green investment is equivalent to the environmental protection investment of enterprises. In general, the research on the corporate green finance at home and abroad mainly focuses on the role and driving factors of the corporate green finance.

Corporate green investment impact on the environment and economy has been widely concerned by scholars at home and abroad, but on this issue is not consistent conclusion, formed three main ideas: first, some scholars believe that corporate green investment has a negative impact on enterprise management, such as green investment has negative externalities and high risk, will use other business decisions, increase the financial risk of the enterprise (Hart and Ahuja, 1996).second, Most of the research has emphasized that green investment increases corporate value (Tang, 2013), reduce environmental pollution (Starr, 2016, Lyeonov et al, 2019, Shen et al.,2021, Ren et al., 2022) and the positive role of improving business performance (Siedschlag et al., 2023), Other studies have shown that, Green investment is closely related to national economic growth (Zeng et al., 2021), And to reduce the emissions of industrial waste gas (Chen and Feng, 2020) and ESG rating improvement (Cao et al., 2023) have positive effects. Third, some scholars believe that the nonlinear impact of green investment on high-quality economic development (Zeng and Zhang, 2021).

About the driving factors of corporate green investment, the domestic and foreign research is relatively rich. In general, existing studies at home and abroad believe that the corporate green finance is mainly influenced by the external environmental policy constraints, the promotion of green finance development, the internal competition incentive of enterprises and the same group effect of other enterprises in peers. Shu and Liao (2022) discussed the impact of green credit policies on different types of corporate green finance, and found that the green credit policies promoted the source control investment of enterprises, and had no significant impact on the terminal governance investment. Wang et al. (2019) investigated the relationship between the development of green finance, debt maturity structure and green enterprise investment, and found that the development of green finance can not only promote the investment of green enterprises, but also produce indirect investment growth effect through the bias effect on the debt maturity structure of enterprises. Siedschlag et al. (2021) used the micro data of the Irish industrial sector during 2008-2016 to investigate the driving factors of corporate green investment, and proved that the main factor affecting corporate green investment is the internal competition incentive. Qian et al. (2023) for the first time investigated the impact of the same group effect on green investment from the perspective of environmental information spillover, and found that the positive environmental protection description of the same group enterprises had a positive spillover impact on the corporate green finance.

2.4. Research Status on the Impact of Low-Carbon City Pilot and Green Finance Reform Pilot on Corporate Green Finance

Some domestic and foreign studies have discussed the relationship between environmental regulation and corporate green finance, but have not reached a consistent conclusion. Taken together, there are three main views. The first view is that environmental regulation can have a positive effect on the corporate green finance, and will promote enterprises to increase their green investment through legal constraints (Leiter et al., 2011) and media supervision (Li et al., 2023). The second view is that strict environmental regulations will inhibit the corporate green finance (Gans, 2012, Hu et al., 2022). The third view is that there is a non-linear relationship of U-shaped (Tang, 2013) or inverted U-type (Li et al., 2016) between environmental regulation and corporate green investment. In addition, some scholars believe that the impact of environmental regulation on the corporate green finance cannot be generalized, but should be analyzed according to the specific types of regulation (Chen et al., 2021, Huang and Lei, 2021). Although these views vary, most studies show that environmental regulation can significantly affect the corporate green finance, but no consensus is the direction and extent of the impact. The differences in the existing studies may be mainly due to the different environmental regulation tools selected, which need to be discussed according to the actual situation. In the study of the micro effect of the Green Finance Reform and Innovation Pilot zone, the influence of the scale and efficiency of enterprises. In general, there are few studies related to domestic and foreign studies on the impact of low-carbon city pilot and green finance pilot on corporate green investment, and no study has discussed the synergistic effect of low-carbon city pilot and green finance pilot policy combination at the enterprise level.

2.5. Literature Review

To sum up, the current domestic and foreign studies have analyzed and explored the Low-Carbon City Pilot Policy, green finance pilot policies and corporate green investment from different perspectives, and draw rich conclusions. However, there are still some limitations in the existing research: First, in the study of low-carbon city pilot and green finance pilot, the existing research focuses more on the effectiveness of pilot policies in terms of environmental and social benefits, and the research related to corporate green investment is not sufficient. Second, there is no study to explore the effect of the policy combination of low-carbon city and green finance pilot zones, and no study to explore the impact of these two policies on the corporate green finance. Third, the theoretical exploration and empirical research on the green investment of the pilot Green Finance Reform and Innovation Pilot zone are not sufficient.

3. THEORETICAL ANALYSIS AND HYPOTHESIS ARE PROPOSED

3.1. Research status of Low-Carbon City Pilot Policy

The primary issue to be addressed in this paper is to explore whether the pilot policies will encourage enterprises to increase green investment. The social responsibility theory holds that in addition to pursuing economic benefit maximization, enterprises also need to realize their own value by maintaining social relations. As mentioned above, the Low-Carbon City Pilot Policy is a city-level environmental policy at the city level to implement China's climate action goals, which is both mandatory and market-oriented, including restrictive and incentive provisions (Zhan, 2018). Among them, the restrictive provisions of the policy set strict emission standards for enterprises and limit carbon emissions, which fully consider the impact of enterprises on the environment and have obvious social welfare orientation. According to the social responsibility theory, corporate environmental social responsibility is one of the important aspects (Wei et al., 2017). In the face of increasingly severe resource constraints and ecological environment damage, enterprises should incorporate green practices into their operation and management, and the government environmental regulation can

further stimulate the environmental responsibility of enterprises, and improve the contradictions and conflicts between economic growth and environmental pollution by increasing green investment. Accordingly, the following assumptions are made:

H1: The Low-Carbon City Pilot Policy can encourage enterprises to increase green investment.

3.2. The Impact of the Pilot Policy of the Green Finance Reform and Innovation Experimental Zone on the Corporate Green Finance

Compared with the traditional command control and market incentive environmental regulation policies, green finance mainly plays the role of environmental governance through credit fund allocation, and affects the corporate green finance through capital orientation and information transmission. First, green financial policies are capital-oriented. When the green finance policy is released, Government departments shall regulate the green finance development mechanism by promulgating relevant green finance policies, To guide the financial system to strengthen environmental risk management and improve the enterprise environmental information disclosure system (Emtairah, 2005;Jaraite, 2014), The financial sector realizes that, whether from the perspective of fulfilling its social responsibility, Or, for the safety of credit funds, Whether environmental risks must be regarded as an important standard for its investment and financing decisions (Zhang et al., 2011;He, et al., 2018), By establishing an incentive mechanism for investment and financing, Taking environmental pollution and biochemistry into the financing cost of enterprises, Control the expansion of low-end industrial projects, such as environmental pollution, Increase financial resources to the green and environmental protection field, Forcing enterprises to invest in environmental protection factors (Luo and Jiao Yue, 2012;Wang and Zhi, 2016). Second, green financial policies are information transmission. Under the constraints of green finance policies, enterprises need to release more green information to the public and investors in order to obtain the support of the government and financial institutions. Financial institutions that provide green financial services will specifically collect and analyze the environmental information disclosed by enterprises, and invest in projects with high environmental benefits and high return on investment. Therefore, enterprises will use more funds for pollution control and environmental protection projects. Therefore, green financial policies promote enterprises to increase green investment through the fund-oriented mechanism and information transmission mechanism. Accordingly, the following assumptions are made:

H2: The pilot policy of Green Finance Reform and Innovation Pilot zone can promote enterprises to increase green investment

3.3. The Impact of the Low-Carbon City and The Green Financial Reform and Innovation Pilot Zone on the Corporate Green Finance

According to the above analysis, the Low-Carbon City Pilot Policy can increase the green investment motivation of enterprises through the punishment effect and incentive effect, the green finance policy can increase the green investment motivation of enterprises through the capital guidance mechanism and information transfer mechanism. Therefore, this paper holds that there may be synergistic effects between the impact of environmental regulation and green finance on corporate green investment, mainly due to the consistency of objectives of the two policies. The main performance is: both improve the green investment motivation of enterprises. According to the previous mechanism of green finance and environmental regulation on corporate green investment, the pilot policy of low-carbon city can force enterprises to carry out environmental governance through punishment effect and encourage enterprises to initiate green investment through incentive effect. Meanwhile, the green finance policy guides enterprises to invest in green projects through capital orientation and information transmission mechanism, and encourages enterprises to make green investment. Therefore, the low carbon city pilot policy and the pilot policy of Green Finance Reform and

Innovation Pilot zone improve the motivation of green investment through different ways. Under the synergistic effect of the two, the motivation of corporate green investment may be stronger due to policy constraints and financial incentives. Accordingly, assumptions 3 and 4 are proposed:

H3: The dual pilot program of Low-Carbon City Pilot Policy and Green Finance Reform and Innovation Pilot zone can promote enterprises to increase green investment.

H4: The effect of the double pilot policies of Low-Carbon City Pilot Policy and Green Finance Reform and Innovation Pilot zone to promote enterprises to increase green investment is more obvious than that of the single pilot policy.

4. RESEARCH DESIGN

4.1. Model Establishment

Due to the low carbon city pilot and green financial reform innovation pilot area pilot are partial, in order to test the low carbon city pilot policy, green financial innovation pilot zone pilot policy and the influence of green investment, this paper Beck et al. (2010), Zhao (2023) and Zhang and Zheng (2023), build many point double difference model is as follows:

$$EPI_{it} = \alpha_0 + \alpha_1 LCCP_{it} + \sum \alpha_j Controls_{it} + \sum Yea + \sum Firm + \varepsilon_{it} \quad (1)$$

$$EPI_{it} = \beta_0 + \beta_1 GFRI_{it} + \sum \beta_j Controls_{it} + \sum Year + \sum Firm + \varepsilon_{it} \quad (2)$$

$$EPI_{it} = \gamma_0 + \gamma_1 DP_{it} + \sum \gamma_j Controls_{it} + \sum Year + \sum Firm + \varepsilon_{it} \quad (3)$$

Model (1) tests the influence of Low-Carbon City Pilot Policy on corporate green investment, $LCCP_{it}$ is the double difference variable representing the Low-Carbon City Pilot Policy, Model (2) tests the influence Green Finance Reform and Innovation Pilot zone on the pilot policy, Model (3) tests the influence of dual pilot policy on corporate green investment, DP_{it} is the double difference variable representing the double pilot policy. In model (1), model (2), and model (3), i and t represent the enterprise and year, respectively, EPI_{it} is the set of explained variables, which represents the corporate green finance i in year t. Referring to the study of Zhang et al. (2019), two methods are adopted: capitalized green investment, the green investment scale of the green projects, the green investment, the expenses related to the green projects, and the related variables are detailed in Table 2. $\sum Year$ and $\sum Firm$ represent the fixed effect of the year and the fixed effect of the company respectively, ε_{it} is the steady standard error of the model.

4.2. Variable Definition

4.2.1. explained variables

This paper measures the scale of corporate green investment from two methods: capitalized expenditure and expense expenditure. First, draw on the practices of existing literature (Zhang et al., 2019; Liao, 2020), and measure the green investment scale of enterprises by using the expenditure of environmental governance, pollution prevention and ecological protection disclosed in the "project of construction under construction" in the balance sheet of listed companies. Second, draw lessons from Zhao (2022), the listed company income statement "management expenses" subject disclosure of the total expenses related to environmental protection (such as greening, eia, resources compensation, etc.) and capitalization spending aggregate enterprise capitalization and expense spending scale, and divided by the enterprise at the end of the total assets standardization.

4.2.2. Interpret variables

The Low-Carbon City Pilot Policy (LCCP), which is a double difference variable at multiple time points. If the city of the company is selected as the pilot city and after the pilot year, $LCCP_{it} = 1$ is considered as the processing group, if the city of the company is not implemented in the year t , then $LCCP_{it} = 0$, as the control group. Considering that the pilot cities were announced in 2010, 2012 and 2017, the first batch of pilot policies included 5 provinces and 8 cities, and the second batch of pilot policies included 1 province and 28 cities, considering the lag of the second batch of pilot policies as 2013, the third pilot batch includes 41 cities (excluding 4 pilot districts and counties). Because of the first and the second batch of pilot contains six provinces, this paper reference the research of Song (2019) and Wang et al. (2022), the low carbon pilot provinces of all cities as low carbon pilot cities, take this approach will lead to some cities repeated in two batches, if a city has multiple policy implementation time, is defined according to the earliest time.

The Pilot Policy of Green Finance Reform and Innovation Pilot zone (GFRI), and the variable construction method is the same as the Low-Carbon City Pilot Policy. If the company province is selected as the pilot area and after the pilot year (2017, 2019), $GFRI=1$ is considered as the treatment group, otherwise $GFRI=0$ is considered as the control group.

Double pilot policy of Low-Carbon City Pilot Policy and Green Finance Reform and Innovation Pilot zone (DP), which is a multi-period double difference variable. If the location of the enterprise is both a Low-Carbon City Pilot Policy pilot and a Green Finance Reform and Innovation Pilot zone in the same year (2017, 2019) and the following year, the value is 1, otherwise it is 0.

4.2.3. Control variables

In order to obtain an objective estimate of the policy effect, this paper refers to Liu Jinke et al. (2022) to control the variables that may affect the corporate green finance over time, including:

Company characteristic indicators that affect the green innovation investment of enterprises. Including company age ($\ln Age$), company size ($\ln Size$). Generally speaking, the longer the listing time, the larger the company will pay more attention to the sustainable development of enterprises, so they will invest more in green projects, while small enterprises will pay more attention to operating conditions and invest less in green projects.

Company financial indicators. Including total assets ($\ln Asset$), asset-liability ratio (Lev), return on equity (ROE), operating income growth rate ($Growth$), cash ratio ($Cash$), enterprise value ($Tobin Q$). The financial indicators of an enterprise can better reflect its operating conditions and cash status, which will affect the investment decisions of green projects.

Corporate governance characteristics. Including the board of directors ($\ln Boardsize$), the proportion of independent directors ($Indpr$) and the shareholding proportion of the largest shareholders ($Top1$). According to the principal-agent theory, there is often a deviation between the company's business goal of pursuing value maximization and the shareholders' goal of pursuing profit maximization, so the corporate governance structure will affect the green investment decisions. Finally, control the year and company fixed effects. The main variable definitions are shown in Table 1:

Table 1. Economic Data Statistics

Variable name	Definition	Meaning
Explained Variables		
EPI1	Enterprise environmental protection investment scale	The amount of investment in environmental protection and pollution control projects plus the total assets of the enterprise at the end of the year
EPI2	Enterprise greening costs and environmental protection investment scale	Greening expenses, sewage fee and other greening expenses and the enterprise environmental protection investment scale plus the annual operating income of the enterprise
Explanatory Variables		
LCCP	Whether to implement the Low-Carbon City Pilot Policy	If the company i becomes a low-carbon city pilot in year t and later, the value is 1, otherwise it is 0
GFRI	Whether to implement the pilot policy of Green Finance Reform and Innovation Pilot zone	If the location of company i becomes the pilot of Green Finance Reform and Innovation Pilot zone in year t, the value is 1, otherwise it is 0
DP	Whether to implement the dual pilot policy	If the location of the company i is both a low-carbon city pilot and the current year t and the following year, the value is 1, otherwise it is 0
Controlled Variables		
Age	Company age	The number of listed years of the enterprise, take the logarithm
Size	company size	The number of employees in the enterprise, take the logarithm
Asset	total assets	Total capital at the end of the year (in 100 million yuan)
Lev	asset-liability ratio	Total liabilities / total assets
ROE	Return on equity	Net profit / Total share capital
Growth	Enterprise growth	Growth rate of total operating revenue, (amount of total operating revenue in this year- -amount of total operating revenue in the same period of last year) / (amount of total operating revenue in the same period of last year)
cash	Operating cash flow	Net cash flow from operating activities / total assets
TobinQ	Tobbin Q	Market value / total assets
Boardsize	Board size	Number of directors
Indep	The proportion of independent directors	Number of independent directors / number of directors
Top1	The largest shareholder's shareholding ratio	Number of shares held of the largest shareholder / total number of shares
Year		Annual fixed effect
Firm		Company fixed effect
Industry		Industry fixed effect
City		Area fixation effect

4.2. Data Source

This paper adopts the multi-point double difference method to study how the pilot policy affects the corporate green finance. Drawing on the practice of relevant literature, the period 2007-2022 is selected as the sample range. The research object is A-share listed companies, excluding the financial industry. Among them, the pilot list and pilot time are from the website of National Development and Reform Commission, corporate green investment data are from GuoTaian Database (CSMR) and manually supplemented through annual reports of listed companies, enterprise financial data are from CSMR database, industry classification refers to national economy classification standard published by National Bureau of Statistics in 2017 (GB / T 4754-2017), the regional characteristic indicators are obtained from the websites of the National Bureau of Statistics, the Ministry of Science and Technology and various authoritative statistical yearbooks such as Urban Statistical Yearbook and China Statistical Yearbook, some data are obtained through calculation.

This paper screens the data as follows: 1) Obtained the data of all listed companies in A-shares from 2007 to 2022 from the CSMAR database, Including the basic information and related financial data of the company. 2) Delete the samples of the financial industry and ST / ST * companies. 3) Consult the relevant national documents to obtain the list of pilot cities corresponding to the pilot policies of the low-carbon city pilot zone and the pilot policies of the Green Finance Reform and Innovation Pilot zone. 4) Match the list of pilot cities with the city where the listed company is headquartered, Delete data that cannot match. 5) Access to corporate green investment data, And to match with the listed companies, Delete data that cannot match. 6) Delete the missing data for the primary variable. 7) To eliminate the effect of the extreme values, Continuous variable were tailed up and down 1%.

5. EMPIRICAL ANALYSIS

5.1. Descriptive Statistics

Table 2. Descriptive statistics of the main variables of green investment

variable	N	mean	sd	min	p50	max
EPI1	2954	0.889	2.391	0	0.147	40.52
EPI2	2954	1.019	2.624	0	0.182	40.52
LCCP	2954	0.497	0.500	0	0	1
GFRI	2954	0.134	0.341	0	0	1
DP	2954	0.100	0.300	0	0	1
Age	2954	2.437	0.638	1.099	2.565	3.434
Size	2954	8.079	1.168	3.850	8.035	13.16
Asset	2954	22.62	1.270	19.57	22.46	28.51
cash	2954	0.959	0.485	0	0.971	25.14
Lev	2954	0.455	0.188	0.0220	0.459	0.979
ROE	2954	0.102	0.0960	0	0.0840	1.751
TobinQ	2954	2.264	1.469	0.759	1.823	16.40
Boardsize	2954	8.807	1.697	5	9	17
Indep	2954	0.373	0.0540	0.250	0.364	0.800
Growth	2954	0.275	1.824	-0.895	0.130	82.79
top1	2954	0.365	0.155	0.0360	0.343	0.882

Table 2 presents the descriptive statistics of the main variables related to corporate green investment. As can be seen from Table 2, the mean values of EPI 1 and EPI 2 calculated by keywords are 0.889% and 1.019%, respectively, indicating little difference in green governance investment of enterprises

measured by capitalization and expense. Besides, it can be found that the proportion of green investment by Chinese listed companies is very low, indicating that the motivation of enterprises to carry out green and low-carbon transformation is not strong. The mean of LCCP was 0.497, the mean of GFRI was 0.134, and the mean of DP was 0.1, indicating that only 10% of the enterprises' regions in the whole sample became dual pilot areas.

5.2. Analysis of the Empirical Results

5.2.1. Benchmark Regression Results for the LCCP

Table 3 shows the relationship between LCCP and corporate green investment. Among them, columns (1) and (3) only control the company and annual fixed effects, and the coefficients of LCCP are 0.474 and 0.434, respectively, which are positive and statistically significant, indicating that LCCP policy can promote enterprises to increase green investment, which verifies the hypothesis 1 of this paper. Column (2) and (4) are listed as the results after the addition of control variables, and the coefficients of the core explanatory variable LCCP were 0.528 and 0.455, respectively, increasing 0.045 and 0.021, respectively. All the results also showed a small increase in R², indicating that the interpretation strength was stronger after the addition of control variables.

Table 3. Benchmark Regression Results for the LCCP

	(1)	(2)	(3)	(4)
variable	EPI1	EPI1	EPI2	EPI2
LCCP	0.474**	0.528**	0.434*	0.455*
	(2.178)	(2.555)	(1.817)	(1.863)
Controls	NO	YES	NO	YES
Year	YES	YES	YES	YES
Firm	YES	YES	YES	YES
Observations	2,954	2,954	2,954	2,954
R-squared	0.577	0.580	0.566	0.569

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

5.2.2. Benchmark Regression Results of the GFRI

Table 4 shows the relationship between GFRI and corporate green investment. Among them, columns (1) and (3) only control the company and annual fixed effects, and the coefficients of GFRI are 0.331 and 0.390, respectively, which are positive and statistically significant, indicating that GFRI policy can promote enterprises to increase green investment, and verifies the hypothesis 2 of this paper.

Table 4. Benchmark Regression Results of the GFRI

	(1)	(2)	(3)	(4)
variable	EPI1	EPI1	EPI2	EPI2
GFRI	0.331*	0.275	0.390**	0.343*
	(1.821)	(1.483)	(2.129)	(1.962)
Controls	NO	YES	NO	YES
Year	YES	YES	YES	YES
Firm	YES	YES	YES	YES
Observations	2,954	2,954	2,954	2,954
R-squared	0.040	0.081	0.040	0.075

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

5.2.3. Regression results of Double pilot policies

Table 5 shows the impact of the dual pilot policy DP on corporate green investment. Column (1) and (3) control only for company and annual fixed effects, and columns (2) and (4) contain control variables. The results showed that the regression coefficients of the key explanatory variables were significantly positive regardless of whether the control variables were included in the model. By verifying the study hypothesis 3 of this paper, we show that the dual pilot policy has achieved the expected effect in promoting enterprises to increase green investment.

Table 5. Benchmark Regression Results of the DP

	(1)	(2)	(3)	(4)
variable	EPI1	EPI1	EPI2	EPI2
DP	0.323**	0.277*	0.390**	0.359**
	(2.330)	(1.895)	(2.577)	(2.656)
Controls	NO	YES	NO	YES
Year	YES	YES	YES	YES
Firm	YES	YES	YES	YES
Observations	2,954	2,954	2,954	2,954
R-squared	0.040	0.081	0.040	0.075

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

5.3. Robustness Test

5.3.1. Parallel trend test

This paper conducts an empirical test using the double difference method, which relies on the parallel trend assumption that the trends of explained variables in pilot and non-pilot areas should be relatively consistent before and after the implementation of the dual pilot policy. In order to exclude the hypothesis that the results may be driven by pre-existing time trends, this paper borrows the usual practices of existing studies (e. g.: Cao Jing et al., 2019, Wang Yongjie et al., 2020, Liu Guangqiang et al., 2022) and builds models (4) for parallel trend testing.as follows:

$$EPI_{it} = \alpha_0 + \alpha_5 Pre_i^{-5} + \alpha_4 Pre_i^{-4} + \alpha_3 Pre_i^{-3} + \alpha_2 Pre_i^{-2} + \alpha_1 Pre_i^{-1} + \alpha_6 Current_{it} + \alpha_7 Post_i^{+1} + \alpha_8 Post_i^{+2} + \alpha_9 Post_i^{+3} + \alpha_{10} Post_i^{+4} + \alpha_{11} Post_i^{+5} + \sum \alpha_j Controls_{it} + \sum Year + \sum Firm + \varepsilon_{it} \quad (4)$$

Among them, Pre_i^{-m} represents m period before the implementation of the policy, $Post_i^{+n}$ represents n period after the implementation of the policy, and $Current_{it}$ represents the current period of the policy implementation, namely 2010, 2013 and 2017. The remaining variables were set at the same level as in the model (1).

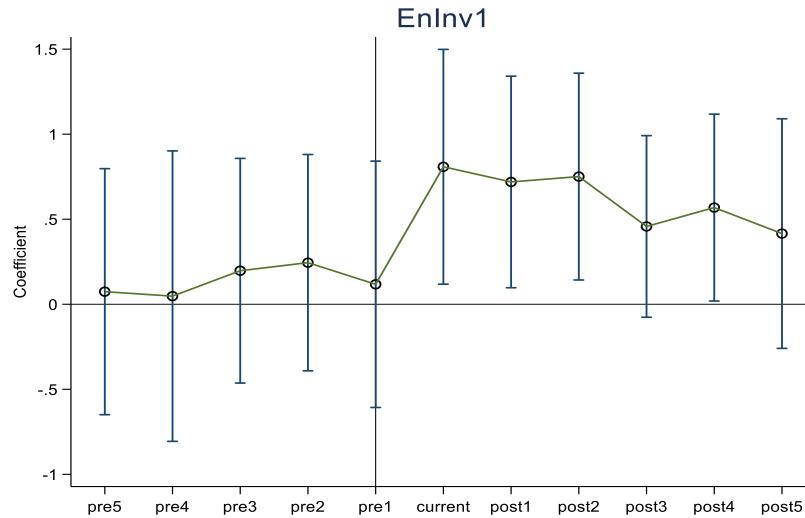


Figure 1. Parallel trend test

Figure 1. report the results of the parallel trend tests for EPI. As shown in the figure, in the first 5 years of the implementation of the policy, the coefficient of DP was not statistically significant, while the coefficient in the current period and 4 years after the policy implementation was significant at at least 1%, consistent with the change trend before the implementation of the policy, basically meeting the parallel trend assumption. At the same time, you can see that the DP coefficient within five years after the implementation is greater than before policy implementation, shows that double pilot policy can promote enterprises to increase green investment, and policy has certain sustained effect, but as the time increase DP coefficient gradually decreases, and the fifth years after the implementation of the coefficient is no longer significant, shows that the policy effect gradually weakened.

5.3.2. PSM-DID

In addition, we also consider the difference between the experimental group and the control group samples, that is, although the DID method separates the average treatment effect of the pilot strategy, it is not strictly a natural experiment. Therefore, the results of this paper may be affected by the sample selectivity bias. For the traditional two-stage DID model, the literature usually solves the difference between group characteristics through the propensity score matching (PSM) method, that is, the dummy variable representing the experimental group as the dependent variable, and then regressed a series of corporate characteristics variables to calculate a propensity score to complete the matching. However, the benchmark regression in this paper adopts the multi-stage DID model. The experimental group receives the policy impact at different times, which will correspond to different control groups, so the traditional PSM method cannot be adopted. Therefore, this paper refers to the same related studies using multi-phase DID method (e. g., Li Xiaoxi et al.,2019; Li and Zhang ,2021; Wu et al. ,2022), and uses the PSM-DID method to conduct the robustness test. The specific practices are as follows: According to the above literature, DP is the company size (Size), financial leverage (Lev), profitability (ROA), Tobin Q (TobinQ), maximum shareholding ratio (Top1) and operating income growth rate (Growth), regression in the whole sample, calculate the bias score, secondly, the 1:1 matching according to the nearest neighbor matching principle, and finally 2990 samples were obtained. Table 6 shows the results of the regression for matching the samples using the propensity scores.

Table 6. Regression Results of the PSM

	(1)	(2)	(3)	(4)
VARIABLES	EPI1	EPI1	EPI2	EPI2
DP	0.501**	0.583**	0.553**	0.641***
	(2.102)	(2.476)	(2.309)	(2.709)
lnAge		1.053		1.199
		(1.039)		(1.181)
lnSize		0.076		0.083
		(0.382)		(0.419)
lnAsset		0.213		0.238
		(0.731)		(0.796)
Cash		-0.201		-0.155
		(-0.446)		(-0.337)
Lev		1.471**		1.512**
		(1.973)		(2.031)
ROE		0.040		-0.000
		(0.203)		(-0.001)
TobinQ		0.048		0.040
		(0.644)		(0.528)
Boardsize		-0.008		0.002
		(-0.100)		(0.020)
Indep		-0.077		-0.037
		(-0.047)		(-0.023)
Growth		0.101		0.105
		(0.764)		(0.760)
top1		0.546		0.420
		(0.483)		(0.350)
Year	YES	YES	YES	YES
Firm	YES	YES	YES	YES
Observations	1,445	1,445	1,445	1,445
R-squared	0.631	0.634	0.645	0.648

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Among them, columns (1) and 3 are the results of simple regression containing only DP, and the coefficient of DP is 0.501 and 0.553 respectively, which are statistically significant and consistent with the benchmark regression results, columns (2) and (4) are the results of DP increasing by 0.072 and 0.088 respectively, indicating that the implementation of double pilot policy has a stronger effect on increasing investment in green governance. The results of Table 6 prove that the results of the benchmark regression in this paper are reliable.

6. CONCLUSION AND POLICY IMPLICATIONS

Building an efficient environmental regulatory system that can continuously promote enterprises to increase green investment is one of the keys to actively respond to climate change and promote the green and low-carbon transformation of enterprises. To this end, the Chinese government has launched a Low-Carbon City Pilot Policy and a pilot green financial reform and innovation pilot policy to encourage enterprises to conduct green behavior. However, most of the existing literature studies the environmental and social benefits of the pilot policies at the national, regional or industry level, or focuses on the driving factors and functions of corporate green investment, and rarely

evaluates the economic benefits of the pilot policies from the perspective of corporate green investment. In view of this, this study is based on the quasi-natural experiment of China low carbon city pilot policy, using the sample of Chinese A-share listed companies from 2007 to 2022, using the multi-point double difference method, to discuss the policy of low carbon city pilot policy, green financial reform and innovation pilot zone and the impact of double pilot policy on the corporate green finance. The main conclusions are as follows: (1) the implementation of the Low-Carbon City Pilot Policy can promote the significant increase of corporate green finance. (2) The implementation of the pilot policy of Green Finance Reform and Innovation Pilot zone can promote the significant increase of corporate green finance. (3) The implementation of the pilot policy combination of low-carbon city and Green Finance Reform and Innovation Pilot zone has a greater impact on corporate green investment than that of the single pilot policy. We believe that this is mainly because the development of green finance can promote the improvement of the financial system and supporting policy measures in the region, and enterprises can quickly reflect the pilot policies of low-carbon cities, thus affecting the green investment decisions of enterprises.

Based on the conclusion of this paper, the corresponding policy suggestions are put forward: (1) firstly, the pilot policies of green finance should continue to play a good role in guiding and supporting the green and low-carbon development of local economy and society, promote enterprises to increase green investment and promote the green transformation of enterprises, (2) strengthen the policy pilot and improve the modern low-carbon economic development system, all pilot cities should earnestly implement the pilot policies, formulate reasonable carbon emission planning, accumulate experience in practice, promote nationwide as soon as possible and promote the comprehensive green transformation, (3) strengthen the synergistic effect of relevant policies. Focus on coordinating low-carbon policies and indirect carbon emission targets, encourage the docking of creative low-carbon cities and green financial reform and innovation pilot zones, and create a new green cutting-edge development model with complementary policies, rewards and supervision, (4) improve the evaluation mechanism of low-carbon city construction to ensure the sustainability of policy effects. In the construction of low-carbon city, a long-term evaluation system of carbon emission effect should be established to evaluate the implementation of each pilot city. Promote the normalization of the supervision work to ensure the sustainability of the construction effect, (5) Enterprises should continue to implement the "five major" development concept, take the green and innovative development concept as the lead, balance the relationship between their short-term interests and environmental responsibility, and effectively promote the transformation from the traditional system to the green system of sustainable development.

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